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Standard Operating Procedure

Operation and Maintenance of Oxygen Cylinders in Health Care Facilities

Contents

Abbreviations

ATM	standard atmosphere, a unit of pressure defined as 101,325 Pa
BiPAP	Bi-level positive airway pressure
COPD	Chronic Obstructive Pulmonary Disease
CPAP	Continuous Positive Airway Pressure
CuM	Cubic Meter
ERP	Emergency Response Plan
ISO	International Organization for Standardization
kL	kilo liter
LMO	Liquid Medical Oxygen
LPM	Lite per Minute
m	Meter
MGPS	Medical Gas Pipeline System
OC	Oxygen Concentrator
PESO	Petroleum and Explosives Safety Organization
PPE	Personal Protective Equipment
PSA	Pressure Swing Adsorption
SDS	Safety Data Sheets
SOP	Standard Operating Procedures
1000 litres	1 Kilolitre (kL)

Introduction

Oxygen therapy is an essential component of medical care. It is used in emergency care, for anesthesia, in surgery, and for managing acute and chronic respiratory conditions. However, the COVID-19 pandemic led to an unprecedented surge in the demand for oxygen supply, given its crucial role in treating COVID-19 patients. The respiratory complications due to COVID-19 can lead to hypoxemia in patients, a condition when the oxygen level in the blood is abnormally low. In such a condition, a patient requires oxygen therapy and access to quality-assured medical oxygen. Reliable access to quality-assured medical oxygen can mean the difference between life and death for patients.

Sometimes, even if oxygen is available, observations suggest that lack of oxygen access to patients in health care settings can be due to insufficient oxygen systems medical gas pipeline; medical grade oxygen generation plant; oxygen concentrators (OC); and low-quality and poorly maintained oxygen delivery equipment like ventilators, concentrators, continuous positive airway pressure (CPAP), and bi-level positive airway pressure (BiPAP). Such shortcomings could be due to deficiencies in clinical and technical training and skills among clinical, technical, and administrative healthcare workers. Thus, creating awareness among the health care professionals and building their capacities to operate and maintain oxygen supply equipment efficiently is of paramount importance. Therefore, an enabling environment is required to streamline efforts to ensure that patients receive oxygen therapy, when needed. These efforts include safeguarding the quality of oxygen supplied by manufacturer, assuring its appropriate administration to the patient, and drastically improving the screening of hypoxemic patients.

Purpose of the Standard Operating Procedure (SOP)

This document, titled "**Operation and Maintenance of Oxygen Cylinder**", provides guidance to all staff on safe use and operation of the compressed oxygen gas cylinders in health care facilities. The SOP includes the following components: types of cylinders, labelling a cylinder, installing a cylinder, using a cylinder, when and how to change a cylinder, handling a cylinder (initial safety checks, general and fire safety considerations), storing and transporting a cylinder, troubleshooting and preventive maintenance of cylinder, calculating oxygen consumption from cylinder, etc.

The SOP intends to bridge knowledge and skill gap among health care facility staff by providing in-depth information on the operation and management of an oxygen cylinder.

Scope

The specifications and guidelines in the "Operations and Maintenance of Oxygen Cylinder" intend to support health facility administrators, clinical practitioners, procurement officers, planning staff, biomedical engineers, infrastructure engineers, and policymakers in the states and at the national level to select, procure, use, and maintain oxygen cylinder. This document may also be of interest to health care workers, academics/researchers, development agencies, non-governmental organizations, regulators, and other stakeholders involved in the management of oxygen systems.

Background

Medical grade oxygen with purity over 90% is a colorless, odorless, and tasteless gas that is required in every health care setting and is used for resuscitation and inhalation therapy. It can be used for medical conditions such as chronic obstructive pulmonary disease (COPD), cyanosis, shock, severe hemorrhage, carbon monoxide

poisoning, trauma, cardiovascular and respiratory arrest, resuscitation, and life support. It is generally stored as a compressed gas in cylinders. Medical oxygen cylinders have a white shoulder and black body as depicted in the figure.

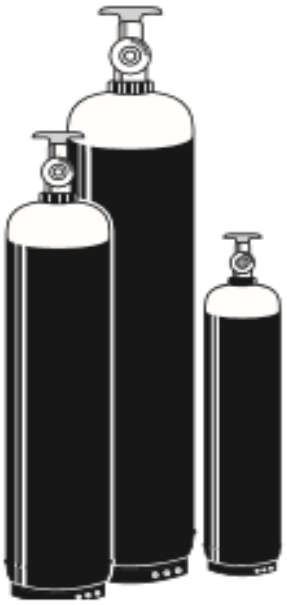

Fig 1: Medical oxygen cylinder

The cylinders are filled at a gas manufacturing plant that manufactures oxygen using cryogenic distillation process, also known as liquid medical oxygen (LMO) process or using pressure swing adsorption (PSA) and transported to health facilities to be connected to manifold systems (groups of cylinders linked in parallel as shown in the following figure 2) that are piped to areas of the health facility; or to be used directly within patient areas. The cylinders are also refilled at LMO-based re-fillers that procure oxygen from LMO manufacturers. The manifold unit consists of a) control panel, b) right and left bank of oxygen cylinders, and c) stand-by arrangement (emergency supply manifold). While less common, cylinders can also be filled using a PSA oxygen plant that is co-located in a health facility and has a high-pressure compressor for cylinder filling purposes. These cylinders require several accessories and fittings to deliver oxygen such as pressure gauges, regulators, flowmeters, and, in some cases, humidifiers. Cylinders also require periodic maintenance, commonly provided by gas suppliers at the point of refilling.

Fig 2: Manifold system

Types of Oxygen Cylinders

Oxygen cylinders are of different sizes. Cylinder sizes for medical gases are named alphabetically, unlike industrial cylinders, which are numbered. In India, most commonly used cylinders are D type (jumbo) and B type (portable) cylinders which contains gaseous oxygen.

Type of oxygen cylinder	Gas capacity in liters	Capacity in cubic meters (m^3)	Water capacity (liters)	Cylinder pressure when full	Weight of oxygen gas (kg)
Type D (Jumbo)	7000	7	~47	~150 bar or ~2000 psi	~9
Type B	1500	1.5	~10	~150 bar or ~2000 psi	~2
Type A	750	0.75	~5	~150 bar or ~2000 psi	~1

Labelling an Oxygen Cylinder

Medical gas cylinders are required to be labelled as the primary means of identifying the contents of the cylinder. The color of the cylinder is only a guide. Labels for gas cylinders can be reduced in size and shape to the dimensions specified in International Organization for Standardization (ISO) 7225 – Gas Cylinders – Precautionary Labels. Figure 3 is an example of a typical label.

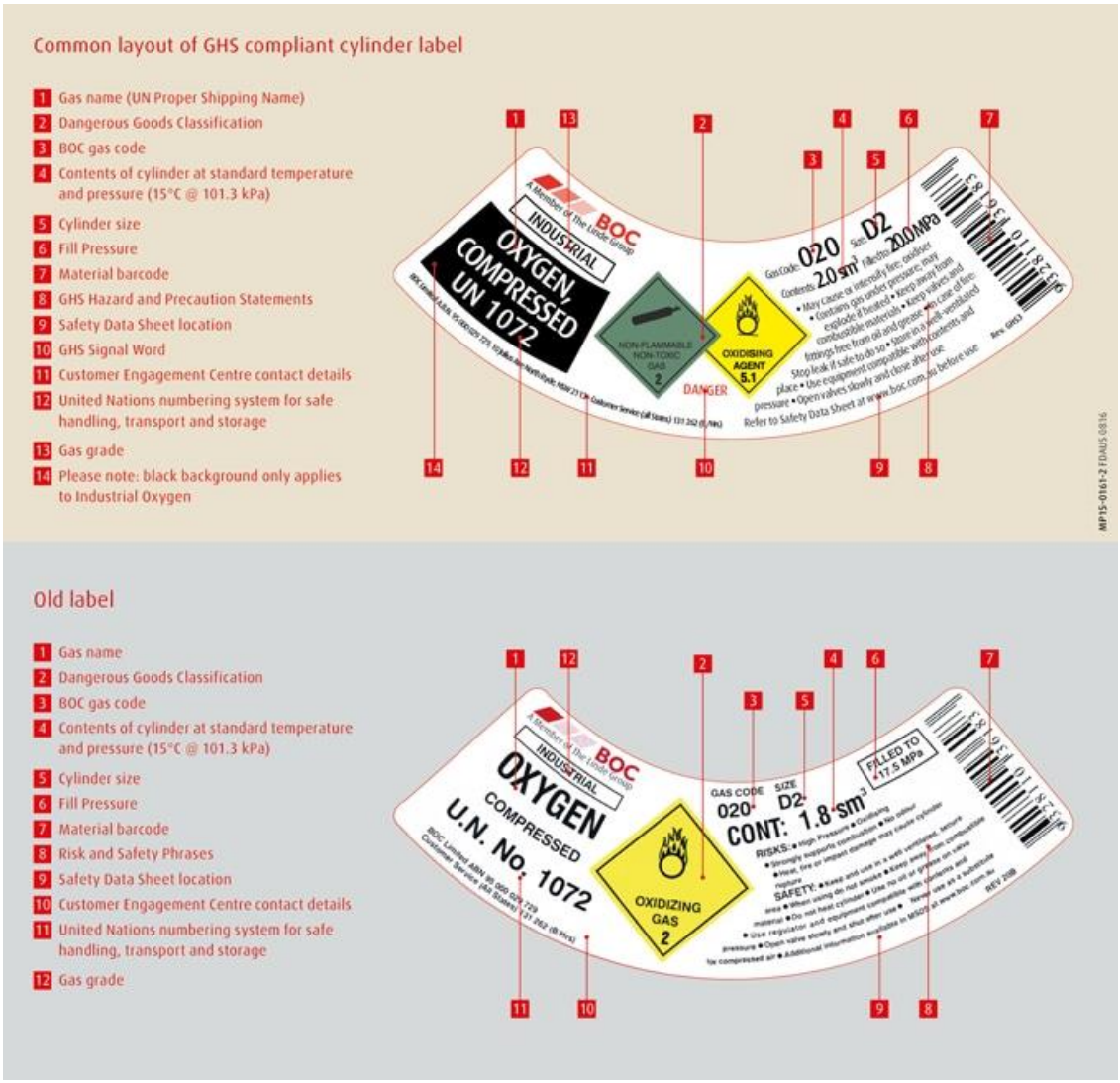

Fig 3: Oxygen cylinder labelling

- Diamond hazard label: This label displays the primary hazard with additional hazard labels that highlight any subsidiary hazards. These labels display the dangerous goods classification number.

- UN number: This label is preceded by the letters UN. The UN number is a number assigned by the United Nations Committee of Experts on the Transport of Dangerous Goods. The UN number for compressed oxygen is UN 1072.
- Proper shipping name.
- Product name (may be omitted if the proper shipping name is identical).
- Signal word, hazard and precautionary statements.
- EC number (if applicable).
- Package size and pressure.
- Company name.
- Address of the gas company.
- Additional company information.
- Contact telephone number.

Procedure

- The hospital should always take medical gases supply only licensed agencies. Industrial oxygen must never be used in the hospital.
- To avoid capital cost, the hospital should make arrangements with the gas agency for supplying their own cylinders, which in any case are rotated. Empty cylinders are given back and filled cylinders are received.
- If cylinders are purchased by the hospital, a register with serial numbers of all the cylinders should be maintained. The hospital authorities through manifold technician will ensure that the empty cylinders are not exchanged from other cylinders. But their own cylinders are filled and brought back to the hospital.
- At the time of purchasing a new cylinder, always insist on Explosive Certificate/Fitness Certificate from the regulatory authorities.
- These cylinders should be sent for inspection periodically as specified by the gas agency. Inspection certificates should be preserved.
- Individual oxygen cylinder should not be used without properly fitting with oxygen therapy accessories such as oxygen regulator, flow meter, and humidifier.
- Oxygen cylinders should be checked for pressure of gas in it. Fix the pressure gauge in the cylinder and check the pressure. The pressure specified for oxygen full cylinder is 137 bar. Anything below 125 should be rejected/returned.

Installing a Cylinder

- Ensure the quality of the oxygen is assured, either by supplier quality certificate, PSA plant logbook, or onsite analyzer testing.
- Oxygen cylinders should be prepared for use and set up in a secure position; vigilance by the operator during preparation is critical.
- Tighten all the connections (between the cylinder and the regulator and between the regulator and the flowmeter) so that oxygen does not leak.

- Before assembling regulators and fittings, it is extremely important to ensure there are no particles of dirt in the cylinder outlet. Use clean compressed air or nitrogen to blow out any loose particles of dirt from the valve sockets.
- Where clean compressed air or nitrogen is not available, particles of dirt and residual moisture can be removed by quickly opening and immediately closing the valve (otherwise known as “snifting”).
- No one should attempt to connect a regulator and/or accessory equipment using improvised hook-ups or adapters. Plastic tape should not be used on a regulator.

Using a Cylinder

- All gas cylinders should be equipped with a functioning gas regulator while in use and a valve opening key should be kept nearby for timely opening/closing of the valve.
- Check the contents gauge on the cylinder before starting to ensure that there is enough gas available. Open the regulator and check the amount of oxygen in the cylinder on the pressure gauge. If the needle is in the red zone, the cylinder is nearly empty and should not be used.
- Valve protection caps are required on all cylinders that are threaded to accommodate a cap unless the cylinder valve is connected for use to a regulator or manifold.
- When the personnel have finished using a compressed gas cylinder, the cylinder valve should be closed and the pressure in the regulator and associated equipment released.

When to Change a Cylinder

- Check your pressure gauge on the regulator unit (or control panel in case of jumbo cylinders connected to manifold) often to make sure you do not run out of oxygen. Please be aware that some manifold systems may have a sound based-alarm system to alert low supply of oxygen in the cylinder.
- Always check the gauge (or control panel) when the valve is turned on.
- When the needle gets closer to zero on the gauge (or the pressure reading is low on control panel), it is time to change the cylinder.
- Be sure to change the cylinder before the needle gets below 56 psi (4 bar).
- If the pressure gauge is broken, please note the weight of an empty and a full cylinder. Regularly note the weight of a cylinder to ensure it is empty before changing it.

How to Change a Cylinder

- Turn off the oxygen flow:
    - Using the cylinder wrench (spanner/key), turn the cylinder on/off valve clockwise to close it.
    - Bleed off the pressure in the valve by opening the flow regulator knob.
    - When the gauge reads zero on the regulator, turn the flow regulator knob to zero.
- Change the cylinder:
    - Remove the regulator unit (including pressure gauge and flowmeter) from the empty cylinder and attach it to a filled cylinder.
- Turn on the oxygen flow:
    - Place the cylinder wrench on the cylinder’s on/off valve, located at the top of the cylinder.

- Open the valve by turning it anti-clockwise one full turn. As the valve opens, the gauge on the regulator will show the amount of pressure in the cylinder. Pressure in a full cylinder will read about 1680-2100 psi (120-150 bar).
- Adjust the flow knob on the regulator until the gauge reaches the flow rate your doctor prescribed.

Oxygen cylinders should have a labelling tag stating its status – Full or Empty or In-use. The "date of service" should also be mentioned on the cylinder. Ideally, the cylinders should be periodically checked once every five years and the "date of test" should be stamped on the cylinders.

Expiry of Oxygen Cylinder:

A full cylinder, if not used, expires in three years. After three years, the cylinder should be emptied, and fresh volume of oxygen gas should be filled.

Handling a Cylinder

- It is observed that oxygen cylinders are transported by rolling them on the ground. This procedure is wrong and compressed gas cylinders should always stay upright.
- Cylinders must always be secured to a trolley when being transported.
- Never roll, drag, or drop cylinders or place them in a way that they strike each other.
- Oxygen cylinders should always be securely restrained to prevent them falling over.
- Oxygen cylinders should be chained to prevent it from falling in storage areas.
- All gas cylinders must have caps over their valves. The valves should be capped (even if the cylinder is empty) when the cylinders are not in use to protect it from damage that might cause leakage. The valve is the most fragile part of a cylinder.
- Empty cylinders should be kept separated from filled ones.
- Cylinders must always be kept away from combustible materials.
- Cylinders should be stored in well-ventilated areas.
- Smoking should be strictly prohibited near cylinder storage areas and 'No Smoking' signs should be clearly placed.
- Cylinders should be transported with care as a broken valve will result in the cylinder shooting away like a rocket, which might cause injuries or even death. Trolley should be used for maneuvering.
- Proper handling of compressed gas cylinders must be known to all hospital personnel. Regular trainings should be conducted for the hospital staff.
- Ensure that the cylinder/gas is the right one for the intended use.
- Oxygen cylinders should always be used in a vertical position, unless specifically designed to be used otherwise.
- Wear appropriate personal protective equipment such as safety shoes and safety spectacles.

Initial Safety Checks

- Medical oxygen cylinders must be inspected and pressure tested every five years by an accredited cylinder test house.

- Medical oxygen has an expiry period of three years. Cylinder test periods and medical oxygen periods must be kept inline.
- Ensure that hands are clean before handling the cylinder. If moisturizers or sunscreen have been used, ensure hands are dry before handling.
- If alcohol-based gel or liquid have recently been used, ensure it is totally evaporated before oxygen use.
- When selecting a cylinder for use, ensure it is clean and dry without any oil or grease on it and it should be free from any damage.
- Check the connection for leaks using the following procedure:
    - Leakage will be revealed by either hissing or, in the case of fuel gases, by an odor. Do not test for leaks with a naked flame.
    - Close valve, remove connection, check, and refit.
    - Never use excessive force when connecting equipment to cylinders.
    - If leak persists, label cylinder and return to BOC or concerned agency.
- Do not use any cleaning material that may contain chlorine or ammonium as they may cause damage to the cylinder package. If any contact with salt water has occurred, then cylinder should be rinsed with fresh water.
- Do not deface or remove any markings, tags, or stencil marks used for identification of contents attached by the gas vendor.
- In case of empty compressed medical oxygen cylinder, ensure the following:
    - Use moderate force to close the cylinder valve and release the pressure in the regulator or tailpipe.
    - Valve outlet cap, where fitted, is replaced.
    - Empty cylinders are immediately returned to the empty cylinder store (dry place/room) for return to BOC Service or concerned agency.
- Compressed medical oxygen cylinders are moved with an appropriate size of handling device.
- Handle with care. The cylinder should not be knocked violently or allowed to fall.
- Do not use the cylinder in the vicinity of persons smoking or near naked lights.
- Always check service/expirer dates before use.

General Safety Considerations

- Personal protective equipment such as eye and hand protection, should be worn when handling oxygen cylinders.
- All compressed medical oxygen gas cylinders (regardless of size) should be secured to racks, walls, work benches, or hand trolleys by a strong chain or strap, capable of preventing the cylinder from falling or being knocked over.
- Cylinder should be securely placed in a cylinder trolley in an upright position by the patient bedside to prevent it from accidental falling. Note that small cylinders, when used for patient transport, may be laid flat, but still need to be firmly secured.
- Do not drop cylinders or allow sharp impacts on cylinders.
- Cover the top of the oxygen cylinder with the cap when it is not in use or when being transported for delivery.
- Set up the cylinder for patient use a safe distance from the patient.

- After connecting the appropriate equipment, turn the flow control off. Carefully open the main valve, then turn up the flow slowly to the desired rate.
- Do not place the cylinder on a patient's bed.
- Before moving cylinders, they must be disconnected from any regulators or manifolds. Apply any protective valve caps before the cylinders are released.
- Cylinders should be moved only on a hand truck or other cart designed for handling gas cylinders.
- No more than one cylinder should be handled at a time except on carts designed to transport more than one cylinder.
- All medical gas cylinders should be clearly labelled to identify the contents. A cylinder without a readable product label should not be used and should be returned to the supplier.
- All defective gas cylinders or equipment should be reported immediately to the supplier for correction or replacement.

Fire Safety Considerations

- Ensure appropriate fire extinguishers are kept nearby and are regularly inspected.
- Keep oxygen cylinders at least several meters from a heat source, open flames, electrical devices, or other possible sources of ignition.
- Put a "No Smoking" sign near oxygen sources in the hospital.
- Check that all nearby electrical circuit breakers and devices are in safe working condition and free from sparking to prevent a serious fire occurrence.

Hazards Classification Labelling and Packaging Regulations – Danger

- May cause or intensify fire; oxidizer (H270).
- Contains gas under pressure; may explode if heated (H280).
- Keep/Store away from clothing, hydrocarbons and combustible materials.
- Keep reduction valves free from grease and oil and from sand and dust too.
- In case of fire, stop leak if safe to do so.
- Protect from sunlight: store in a well-ventilated area.
- Contact with combustible material may cause fire.
- Keep out of the reach of children.

Fire Fighting Measures

In case of fire,

- If it is safe to move the cylinders, then:
  - Close the cylinder valve to stop the flow of product.
  - Move the cylinders away from source of heat.
- If it is not safe to move the cylinders, then:
  - Use water and fire extinguishers from a protected position.

All types of fire extinguishers may be used when dealing with a fire involving medical oxygen cylinder. Fire and rescue team should be informed that medical oxygen cylinders are present inside the building and share their location.

Exposure Controls

- Adequate ventilation must be ensured when using medical oxygen cylinders.
- If clothes get impregnated with oxygen (due to leak), stay away from source of ignition or open flames. Clothing impregnated with oxygen should be advised to ventilate in fresh air for up to 15 minutes.

Disposal Considerations

It is recommended that medical oxygen cylinders should not be vented after use; they should be returned to BOC, with any residual gas*, where they will be vented before refilling in a safe environment. This is done due to the possible chance of moisture being entrapped into the cylinder.

Storing a Cylinder

- Oxygen cylinders should not be stored for excessive periods of time. Only purchase sufficient quantities to cover short-term needs.
- Properly secure the cylinder at all times: straps, belts, or chains.
- Always physically separate full and empty medical gas cylinders. Ambulatory organizations can do this by using separate racks, physical barriers or by color coding the storage rack.
- Label the cylinders clearly (open/empty or full/unopened) to avoid confusion and reduce delay while selecting between full, partial, and empty cylinders.
- Store in well-ventilated, clean, dry conditions, not exposed to extremes of heat or cold.
- Oxygen cylinders should be stored away from sources of ignition, other flammable materials.
- Protect cylinder and all other fittings from contamination by oil and grease.
- Never use a single-use and/or re-use an industrial gas cylinder for refilling medical oxygen.
- Store oxygen cylinders securely when they are not in use and should be properly restrained.
- **PESO license is required to store more than 200 cylinders at a facility.**

Transporting a Cylinder

- Use cylinder trolley when handling gas cylinders.
- Fit suitable protective valve caps and covers to cylinders before transporting.
- Transport cylinders with valve caps.
- Do not lift cylinders by the cap.
- Do not transport with the regulator attached.
- Cylinders must be fastened securely in upright position.
- Cylinders must be located in a compartment separated from the driver.
- Ensure all cylinders are adequately restrained.

- The vehicle must be adequately ventilated, and the load be secured. Signs should be carried on the outside to inform the public of what is being carried. Ensure that the driver is aware of the potential hazards and the detailed information sheet is carried and understood in the event of any emergency.

Roles and Responsibilities of Hospital Staff

Duties of Supervisor

- To ensure that relevant staff receive appropriate training specific to the compressed gases they are handling and using.
- To ensure that compressed gases are used only for the intended purpose and in accordance with defined procedures and rules.
- To ensure that applicable Safety Data Sheets (SDS), Emergency Response Plan (ERP), or other relevant literature is made readily available to staff.
- To provide staff and visitors with appropriate personal protective equipment (PPE).
- To provide appropriate supervision to staff.
- To ensure staff and visitors adhere to applicable occupational health and safety regulations for the use of compressed gases.
- To investigate reported incidents to determine the cause and to develop appropriate preventative measures to minimize a recurrence.
- To maintain appropriate records pertaining to the handling and use of compressed gases including an up-to-date inventory, training records, and reported incidents.

Duties of Staff

- To adhere to defined procedures and rules and applicable occupational health and safety regulations for the use of compressed oxygen gas.
- To wear and maintain the personal protective equipment.
- To ensure the use of correct medical gas and that it is used within its expiry date (found on batch label of the cylinder).
- To check for enough oxygen in the cylinder using gauge and valve on the cylinder.
- To remove the tamper evident seal and cover that is fitted over the valve outlets.
- To ensure that the flow selector is set to zero before using the (black) hand wheel to open the cylinder valve.
- To open the cylinder valve slowly (turn anti clockwise until it stops) and check for any leak.
- To ensure the outlet (fir tree connector) is free of obstruction. If any dirt or other obstruction is seen, slowly turn the flow dial to maximum to clear it.
- To ensure that the correct equipment is selected for connection to the cylinder.
- To connect tubing to the fir tree connector and select appropriate flow rate.
- To turn off the valve turned off, when not in use, using only moderate force.
- To notify their supervisor of identified hazards related to the use of compressed oxygen gas.
- To notify their supervisor of any incident related to the use of compressed oxygen gas.

Duties of Manifold Operator

- To ensure that all the cylinders in the Manifold Room are OK every morning.

- To open the required number of cylinders to ensure the correct pressure in the pipelines.
- To use the cylinders from one side of the manifold cylinders bank (right sight or left side). The cylinders of the other side should be sent for refilling as soon as all the cylinders of that bank are empty.
- To check all cylinders for leakage using soap water mixture.
- To maintain a stock of required tools with him in the manifold room.
- After checking the manifold room, the staff should take a round of the hospital to check all the outlets, and to ensure their proper functioning from staff posted there.
- To repair or arrange to repair any defects in the outlets or in the pipeline including main manifold room.
- To place order for refilling of the cylinders in consultation with the authorized officer.
- To ensure supply of oxygen in other areas without central pipeline.
- To help the operation theatre technician in maintaining the Boyle's machine.
- To change the ward's cylinder.
- To report all the major problems to the administrators immediately.

Duties of Safety Resources

- To provide information and advice in health, safety, and environmental protection including on the safe use of compressed gases.
- To develop and administer health, safety, and environmental programs.
- To provide health and safety training.
- To provide hazardous waste disposal services.
- To respond to reported incidents and spills of hazardous materials.
- To support regulatory compliance.

User Care and Preventive Maintenance of Cylinders

Table 1 provides daily and weekly guidance for user care and routine maintenance of oxygen cylinders and associated accessories. However, preventive maintenance of the cylinders should be carried out periodically (every 5 to 10 years) by the gas supplier, and a colored cylinder test ring may be fitted around the cylinder neck indicating the next due date for testing.

Table 1: Daily and weekly guidance for user care and routine maintenance of oxygen cylinders and associated accessories

Schedule Period	Activity	Check
Daily	Cleaning	Ensure delivery tubes and masks are decontaminated. If humidifier bottle is used, disinfect and refill with clean water.
	Visual Checks	Check cylinder is correct type and correctly labelled. Check all parts are fitted tightly and correctly.
	Function	Before use, ensure cylinder has sufficient pressure. Ensure flow is sufficient for intended use.

		Close cylinder valve after each use.
Weekly	Cleaning	Clean cylinder, valve and flowmeter with damp cloth.
	Visual Checks	Check for leakage: hissing sound or reduction in pressure.
	Function	Remove valve dust with brief, fast oxygen flow checks. Check flow can be varied using flow control.

Troubleshooting of Cylinders

Table 2 provides troubleshooting tips for common issues with oxygen cylinders and associated accessories. Please refer to user and service manuals for more detailed guidance.

Table 2: Troubleshooting tips for common issues with oxygen cylinders and associated accessories

Problem or Fault	Possible Cause	Solution
No oxygen is flowing	Empty cylinder	Replace cylinder.
Leakage from cylinder or flowmeter	Flowmeter knob or cylinderflow valve is closed	Open the valves, and then check the meterregisters flow.
	Faulty regulator	Close all the valves and replace the regulator.
	Cylinder is not connected to pressure regulator properly	Tighten all fittings.
	Faulty or missing washer between regulator and cylinder	Replace the washer.
	Flowmeter seal damaged or loose.	Replace sealing of the washer and realignthe flowmeter.
	Cylinder faulty.	Label faulty cylinder and take appropriate action.
Leakage cannot be located	Leakage too small to be heard	Apply detergent solution (NOT oily soap) to the joints. There will be bubbles at the leakage point. Clean/replace the washer andtighten the joint.
Flowmeter ball not moving, yet oxygen is flowing	Faulty flowmeter.	Close all the valves, disconnect flowmeter, and clean the flowmeter. Reconnect and test.

		If problem persists, replace the flowmeter.
Pressure gauge does not show pressure, yet oxygen is flowing	Faulty pressure gauge	Replace pressure gauge.

Calculating Oxygen Consumption from Cylinders

Calculating oxygen consumption from cylinders

(i) D type:

$$\frac{No.\ of\ D\ type\ cylinders \times 7}{770}\ \left(in\ \frac{\text{MT}}{\text{day}}\right) \qquad \text{For eg } \frac{103 \text{ x } 7}{770} = 1\ \frac{\text{MT}}{\text{day}}$$

(ii) B type:

$$\frac{No.\ of\ B\ type\ cylinders \times 1.5}{770}\ \left(in\ \frac{\text{MT}}{\text{day}}\right) \qquad \text{For eg } \frac{103 \text{ x } 1.5}{770} = 0.21\ \frac{\text{MT}}{\text{day}}$$

How quickly will your cylinder oxygen supply end?

(i) D type:

$$\frac{(\textbf{\textit{Current pressue in bar}}\ -10\ bar\ ) \text{ x } 47}{\text{flow rate (in liter per minute} - \text{LPM)}}\text{, (in minutes)} \qquad \text{For eg } \frac{(120-10)\ 47}{24} = \sim 215\ mins$$

(ii) B type:

$$\frac{(\textbf{\textit{Current pressue in bar}}\ -10\ bar\ ) \text{ x } 10}{\text{flow rate (in LPM)}}\text{, (in minutes)} \qquad \text{For eg } \frac{(120-10)\ 10}{24} = \sim 45\ mins$$

- Current pressure in bar - the pressure of oxygen gas in the cylinder.
- 10 bar - approximate pressure in empty oxygen cylinder.
- 47 & 10 - water capacities of D type and B type cylinders respectively.
- Flow rate - set flow rate of Oxygen in liters per minute (LPM), as seen on the flow meter.

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